NJDOT Bureau of Research
QUARTERLY PROGRESS REPORT

Project Title:	Analysis of Fatal Accidents	
RFP NUMBER: 2007-05		NJDOT RESEARCH PROJECT MANAGER: Edward S. Kondrath
TASK ORDER NUMBER:		PRINCIPAL INVESTIGATORS: Yusuf Mehta, Ph.D, P.E., Rowan Univ. Clay Gabler, Ph.D., Virginia Tech
Project Starting Date: 1/1/2007 **Original** Project Ending Date: 12/31/2007 **Modified Completion Date: 06/30/2008**		Period Starting Date: January 1, 2008 Period Ending Date: March 31, 2008

Task	**% of Total**	**% of Task this quarter**	**% of Task to date**	**% of Total Complete**
1. Literature Search	10	0	100	10
2. Identify Existing Fatality-Related Databases and Fatality Data Sets in New Jersey	10	0	100	10
3. Determine Current Practices for Maintaining Fatal Accident Records at Other Agencies	10	55	100	10
4. Develop and Report Recommendations for an Integrated System of Crash Data	10	0	100	10
5. Conduct Pilot Studies using the Prototype Integrated Database	50	50	100	50
Final Report	10	0	0	0
TOTAL	100			90

ANALYSIS OF FATAL ACCIDENTS

Quarterly Progress Report – March 2008

Project Objectives:

The goal of this study is to determine the feasibility of an integrated database for the analysis of fatal accidents in New Jersey. The specific objectives are to:

1) Determine how New Jersey fatal accident datasets can be integrated.

2) Demonstrate the value of this integrated database by the system in a series of pilot case studies

Project Abstract:

In 2005 there were 691 fatal crashes and 748 fatalities in New Jersey. Each of these tragic events occurred despite the millions of dollars expended by New Jersey each year on redesigned intersections, aggressive traffic law enforcement, driver education programs, EMS funding, and numerous other safety initiatives. Despite the success of these programs, the belief is that even greater fatality reductions are possible. If there were better data describing the driver-vehicle-road interactions which lead to fatal crashes, highway safety funds could be better targeted to reduce traffic fatalities.

Unfortunately, the data to adequately understand fatal crashes are simply not readily available to New Jersey policy makers. The encouraging fact is that New Jersey has extensive crash databases, exemplified by the New Jersey Crash Record system which contains summary records of over 300,000 police reported accidents each year. In addition, several state agencies in New Jersey maintain datasets which describe additional facets of the crash event. However, to date, for reasons ranging from privacy concerns to incompatible data formats, these datasets have been seldom linked for a comprehensive perspective of highway safety.

The research program will develop a pilot system which links fatal crash data with other associated state data files. By linking these databases, there is an opportunity to investigate the root causes of fatalities in ways that are not possible through analysis of a single database. This research project will consider the following four databases: (1) NJ Crash Records, (2) MVC Fatal Accident Database, (3) Fatal Analysis Reporting System (FARS), and (4) the NJ State Police Fatal Investigations Division database. The project will undertake two case studies to demonstrate the value of the linked data system.

1. **Progress this quarter by task:**

   <u>Task 1 –Literature Survey</u>

   - Completed

   <u>Task 2 – Identify Existing Fatality – Related Databases and Fatality Data Sets in New Jersey.</u>

   - Completed

   <u>Task 3 – Determine Current Practices for maintaining Fatal Accident Records at other agencies.</u>

   - Completed

   <u>Task 4 – Develop and Report Recommendations for an Integrated System of Crash Data</u>

   - Completed

   <u>Task 5 – Conduct Pilot Studies using the Prototype Integrated Database</u>

   - Our case study entitled "Evaluation of the Crash Fatality Risk for Older Adults in New Jersey" has been completed, and is included in the appendix for review of the Project Panel.

2. **Proposed activities for next quarter by task**

   - Complete Final Report

3. **List of deliverables provided in this quarter by task**

   - none

4. **Progress on Implementation and Training Activities**

   - None Scheduled

5. **Problems/Proposed Solutions**

   - none

Total Project Budget	$ 144,527
Modified Contract Amount:	
Total Project Expenditure to date	$ 130,074
% of Total Project Budget Expended	90%

Appendix A

Evaluation of the Crash Fatality Risk for Older Adults in New Jersey

Clay Gabler

Virginia Tech
Department of Mechanical Engineering
Blacksburg, VA

2 April 2008

Evaluation of the Crash Fatality Risk for Older Adults in New Jersey

Clay Gabler
Virginia Tech
Draft - 4/02/2008

Summary

This case study has investigated the fatality risk of older adults involved in traffic crashes in New Jersey. For this study, older adults were defined those individuals 65 years of age or older. The findings were as follows:

- In 2006, 134 older adults were fatally injured in traffic crashes in New Jersey.

- Older adults comprised less than 8% of all persons exposed to traffic crashes in New Jersey, but accounted for 20% of all New Jersey traffic crash fatalities per year. This underscores the fragility of older persons in traffic crashes.

- Most older adults killed in traffic fatalities were occupants of a passenger vehicle (67%). Fatally-injured older adults in motor vehicles were belted (64%). Surprisingly, more than 1 in 4 (27%) of all fatally-injured older adults were pedestrians.

- Alcohol use does not appear to be less a risk factor for older adult drivers than for young drivers. Only 6% of older adult drivers involved in fatal crashes had been drinking, as compared to 18% of younger drivers.

- Nearly 80% of fatal accidents involving older adult drivers in New Jersey occurred in daylight. This statistic suggests that older drivers may be choosing to avoid driving at night either because of self-regulation or because of licensing restrictions.

- Most fatal accidents involving older adult drivers in New Jersey (46%) occurred at an intersection. In contrast, both teen and adult drivers aged 21-64 are more likely to be involved in a fatal crash at non-intersections. Older drivers may have an elevated risk of intersection crashes because of a decreased ability to judge the amount of time necessary to clear an intersection.

- Older adult drivers who were involved in fatal crashes were 4.9 times more likely to have been ill or have blacked out than adult drivers aged 21-64. Older adult drivers were 10% more likely to have been drowsy or asleep than adult drivers, and 40% more likely to have been attentive or distracted than adult drivers.

Introduction and Objective

The objective of this study is to examine the risk of traffic accident-related fatalities among older adults in New Jersey. The specific objectives are to 1) determine the characteristics of fatally-injured older adults in traffic crashes, and 2) identify the factors which lead to fatal crashes involving older adult drivers.

Approach

The evaluation was based upon the analysis of NJ highway fatality records extracted from the Fatality Analysis Reporting System (FARS) database for the years 1991-2006. FARS is a national census of all highway fatalities which is maintained by the National Highway Traffic Safety Administration (NHTSA). Throughout the study which follows, the population has been separated into four age categories: 1) children defined to be 0-14 years of age, 2) young persons defined to be 15-20 years of age, 3) adults defined to be 21-64 years of age, and 4) older adults defined to be 65 years of age and older.

Results

Figure 1 presents the traffic fatalities in New Jersey from 1991-2006 as a function of the age of the fatally injured persons. Since 1993, fatalities among older adults have declined 38% from a peak of 217 in 1993 to 134 fatalities in 2006.

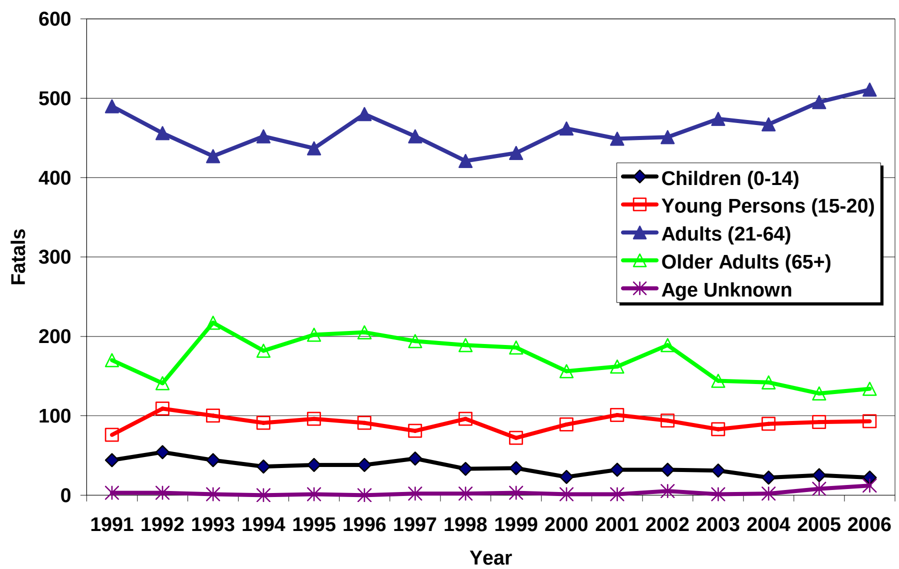

Figure 1. New Jersey Traffic Fatalities from 1991-2005

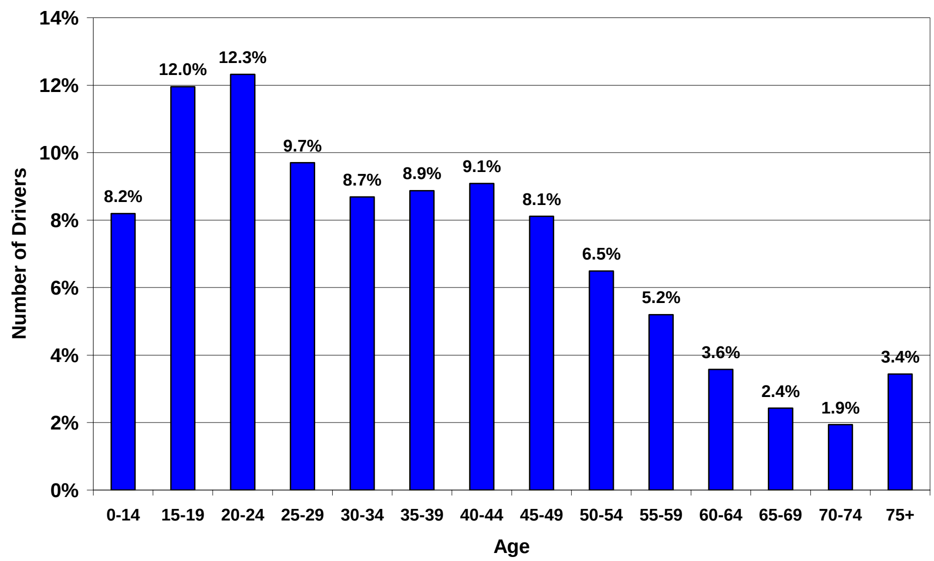

Figure 2. Age Distribution of persons involved in New Jersey traffic accidents (NJCRASH 2005)

As shown in Figure 3, older adults accounted for 7.8% of all persons exposed to New Jersey traffic crashes whether fatal or non-fatal. However, as shown in Figure 3, older adults accounted for 20% of all New Jersey traffic crash fatalities per year. Persons of 75 years age and older comprised only 3% of persons exposed to traffic crashes, but accounted for 13% of all fatally-injured occupants. This underscores the fragility of these older persons in traffic crashes.

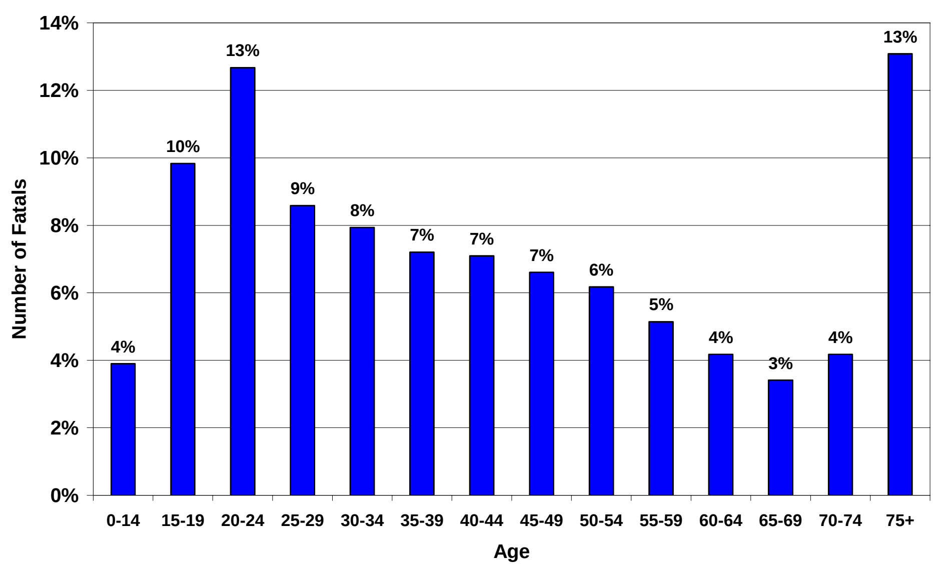

Figure 3. New Jersey Traffic Fatalities by age (FARS 2001-2005)

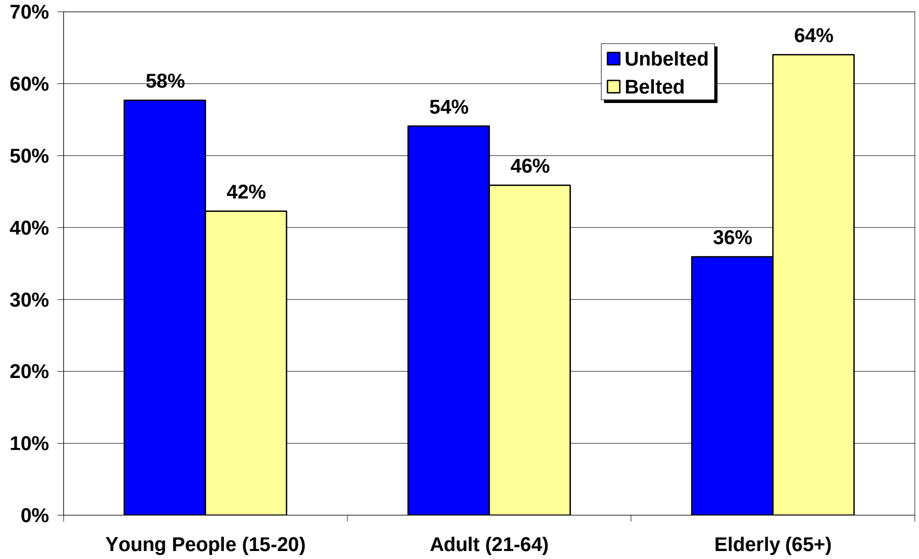

Figure 4. Age Distribution of New Jersey Fatalities by Safety Belt Usage (FARS 2004-2006)

As shown in Figure 4, most fatally-injured older adults (64%) were belted. In contrast, over half of all fatally injured younger persons were unbelted. Even when belted however, the fatality rate among older adults reflects the fact that older adults are less tolerant of injury. These findings are consistent with U.S. experience showing that older adults are more likely to wear seat belts (Nelson et al, 1998).

Figure 5 presents traffic fatalities for each age group as a function of gender from 2004-2006. Fatally-injured older adults were approximately split between male (54%) or female (46%). For younger age groups, a fatality was much more likely to be male than female. For teens, two-thirds of the fatalities are male while for adults 21-64 years old over three-fourths of the fatally injured persons are male.

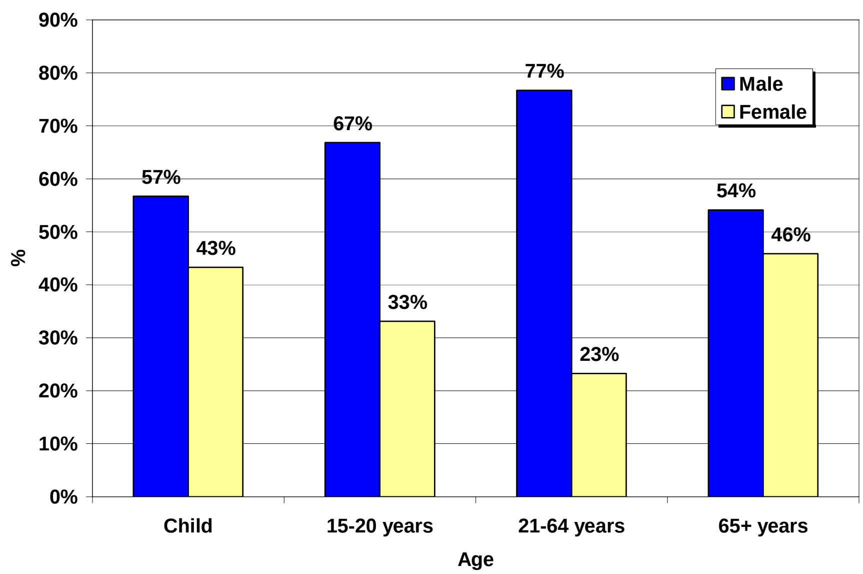

Figure 5. Distribution of NJ Traffic Fatalities by Gender for each age group from 2004-2006

Figure 6 displays the distribution of traffic fatalities from 2002-2006 by the type of vehicle in which the person was a driver or passenger. Note that this figure also contains fatally-injured pedestrians, bicyclists, and motorcyclists. LTV refers to light trucks and vans, e.g. SUVs and pickups. Passenger vehicles include cars and LTVs. Most older adults killed in traffic fatalities were occupants of a passenger vehicle (67%). Surprisingly, more than 1 in 4 (27%) of all fatally-injured older adults were pedestrians. Previous research studies have shown that older adults have decreased perception of the time necessary to walk across an intersection. The elevated number of fatally-injured older pedestrians may be related to the need for older adults to allow more time to cross an intersection.

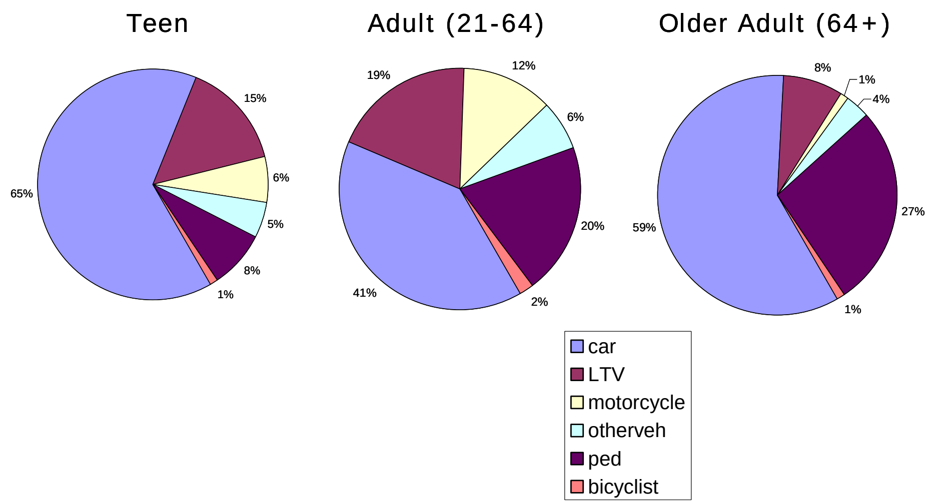

Figure 6. Distribution of NJ Traffic Fatalities incurred by Victim's Vehicle Type (FARS 2002-2006)

Older Adult Drivers

This section investigates the behavior of older adult drivers involved in fatal crashes. In the analysis which follows, the younger driver was involved in, but not necessarily fatally injured, in the fatal crash. Concerns are sometimes raised that older adult drivers who exhibit these symptoms may be hazardous not only to themselves but also to other road users as well. Older adult drivers may be at increased risk of a crash for reasons including slower reaction times (Cooper, 1990; Schlag, 1993), decreased vision (McGwin et al, 2000), medications (Ray et al, 1992), and medical problems, e.g. diabetes, dementia, or syncope.

As shown in Figure 7, 8.4% of all drivers in NJ crashes, both fatal and non-fatal, were 65 years of age or older. Note that 3.6% of drivers in NJ crashes were 75 years of age or older.

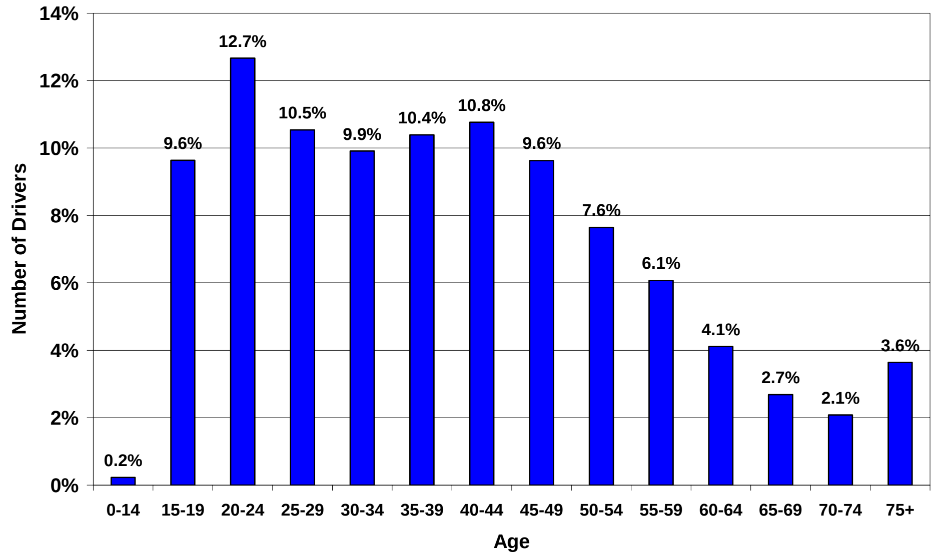

Figure 7. Distribution of Driver Ages in New Jersey Traffic Crashes (NJCRASH 2005)

Alcohol use does not appear to be as prevalent a risk factor for older adult drivers as for young drivers. As shown in Figure 8, only 6% of older adult drivers involved in fatal crashes had been drinking. By contrast, approximately 20% of both younger drivers and adult drivers aged 21-64 involved in fatal crashes had been drinking. The presence of alcohol was obtained from police accident reports and does not necessarily mean that the driver was intoxicated.

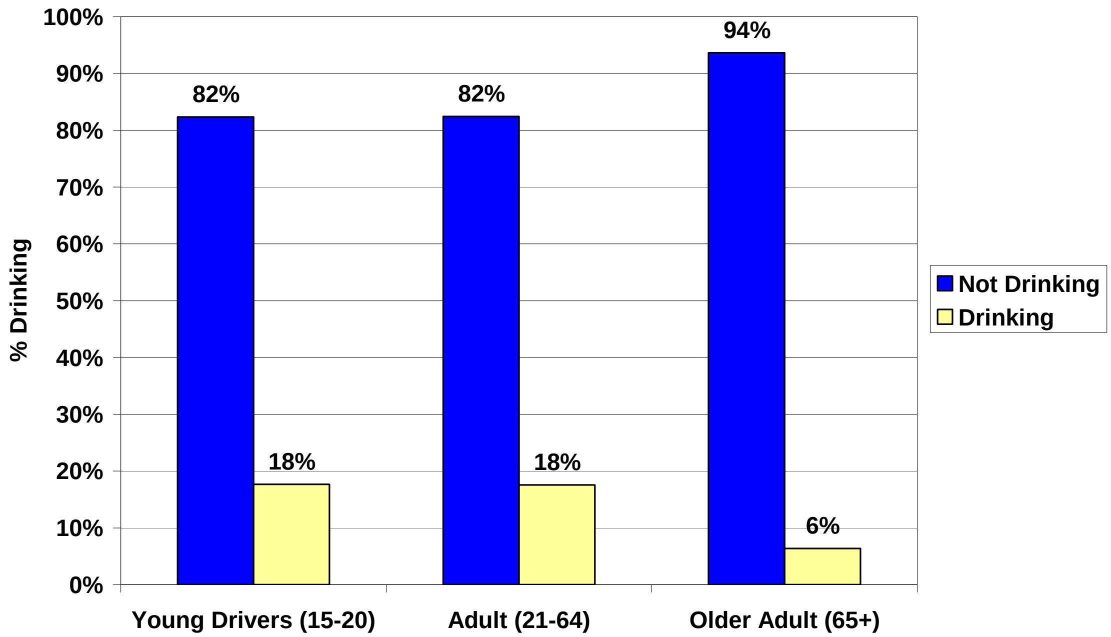

Figure 8. Drivers involved in fatal crashes in NJ by alcohol involvement and age (FARS2004-2006)

The night vision of drivers degrades with age, and can be a crash risk factor for older drivers. Note however that nearly 80% of fatal accidents involving older adult drivers occurred in daylight. This statistic suggests that older drivers may be choosing to avoid driving at night either because of self-regulation or because of licensing restrictions.

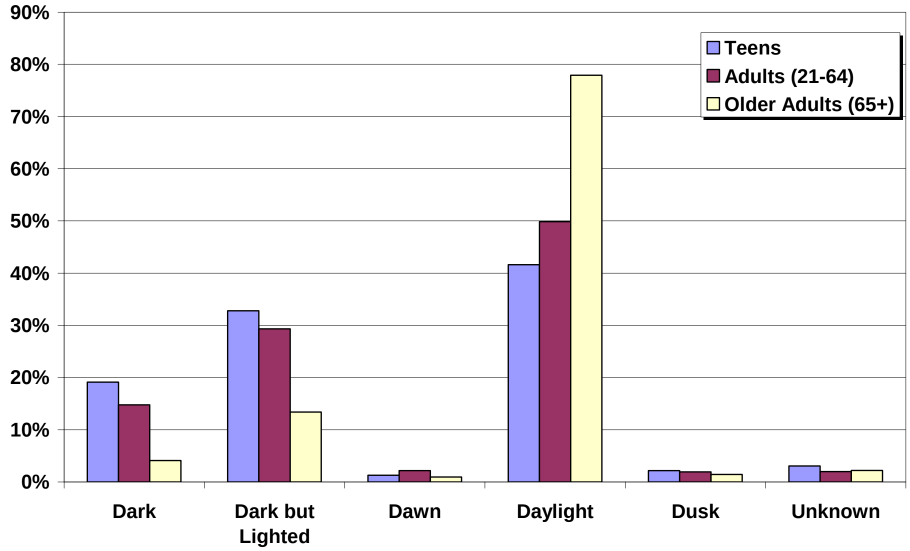

Figure 9. Drivers involved in fatal crashes in NJ by lighting condition at time of accident (FARS2001-2006)

As shown in Figure 10, most fatal accidents involving older adult drivers in New Jersey (46%) occurred at an intersection. An example would be an older driver turning left in front of oncoming traffic. In contrast, both teen and adult drivers aged 21-64 are more likely to be involved in a fatal crash at non-intersections. Many crashes involving teen drivers are single-vehicle run-off road crashes reflecting their relative lack of driving experience or risk taking behavior. Older drivers may have an elevated risk of intersection crashes because of a decreased ability to judge the amount of time necessary to clear an intersection (Preusser et al, 1998).

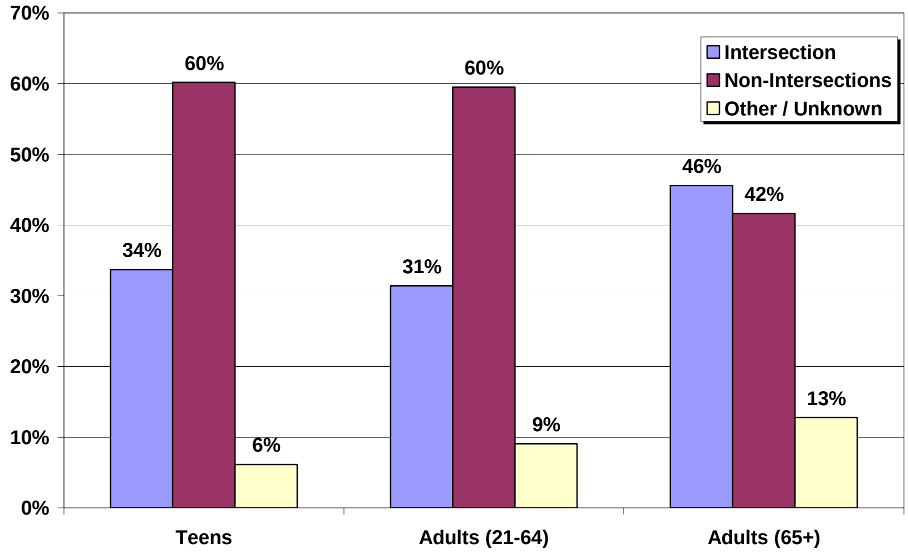

Figure 10. Drivers involved in fatal crashes in NJ by location of accident site to a traffic intersection (FARS2001-2006)

The fraction of fatal crashes as a function of roadway type appears to be independent of age. As shown in Figure 11, most fatal crashes involving all three age groups occurred on urban roads. Nationally, a higher percentage of fatal crashes are experienced on rural roads. The elevated risk in NJ likely simply reflects the fact that NJ is a densely populated state and has a higher percentage of urban roads than elsewhere in the U.S.

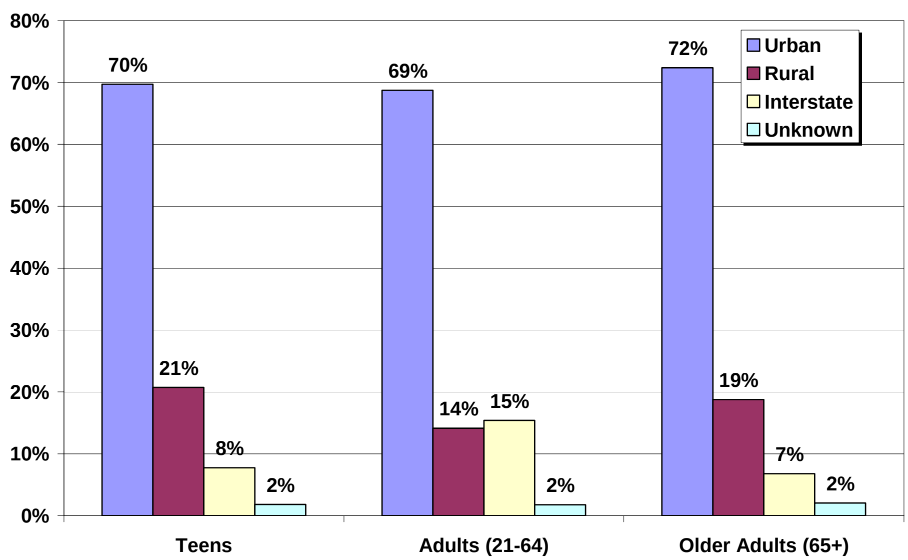

Figure 11. Drivers involved in fatal crashes in NJ by type of roadway (FARS2001-2006)

Factors associated with Elderly Drivers involved in Fatal Crashes

One of our objectives was to explore the factors which may cause older adult drivers to have a elevated risk of being involved in a fatal crash. The analysis which follows was based upon the use of Driver Crash Related Factors variables in FARS. Our analysis explored the following factors:

- Medical risk (ill or passed out)
- Drowsiness
- Inattentiveness
- Medication
- Physical Disabilities

Medical risk includes drivers who blacked-out or who were ill, e.g. from a heart attack. Physical disabilities include drivers identified as being paraplegic, requiring use of a wheelchair, suffering from previous injuries or suffering from any other physical impairment.

In the analysis which follows, we present the proportion of fatal crashes associated with each crash-related factor in comparison with all fatal crashes. This proportion was computed as follows:

$$\text{Proportion Crash Factor - Related} = \frac{\text{Number of Drivers Identified with Factor}}{\text{All Drivers Involved in Fatal Crashes}}$$

As shown in Figure 12, approximately 3% of all older adult drivers involved in fatal crashes either blacked out or was identified ill. This is a small percentage of all older drivers, but is nearly 5 times higher than younger adult drivers. Note that this factor was not a factor in any of the teen driver fatal crashes. Teens are presumably healthier and less prone to this medical risk than older drivers.

A similar approach was followed for the other crash-related factors in our study. In all cases, the percentage of fatal crashes associated with each factor was a relatively small percentage of all fatal crashes. Rather than present these percentages, our analysis presents these proportions relative to the experience of the adult age group (21-64). Figure 13 presents these relative proportions for 1) illness/blackout, 2) inattention, and 3) drowsiness/asleep. Surprisingly the frequency of drivers associated with medication-related or physical disabilities was independent of age (not shown in the figure).

$$\text{Relative Proportion Crash Factor - Related} = \frac{\text{Proportion Crash} - \text{Factor Related in this Age Group}}{\text{Proportion Crash} - \text{Factor Related in Adult Age Group}}$$

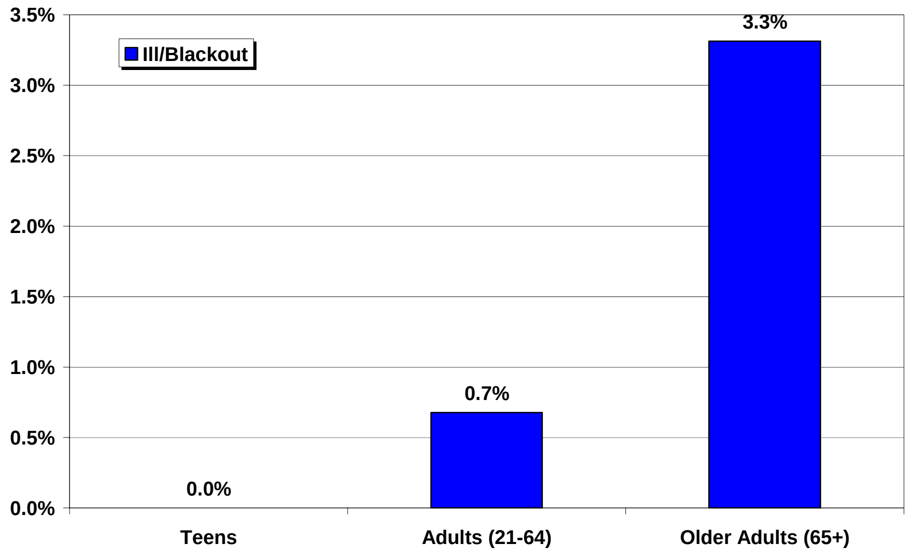

Figure 12. Proportion of Drivers in an age group who blacked-out or who was identified as ill and was involved in a fatal crash (FARS 2002-2006)

Older adult drivers who were involved in fatal crashes were 4.9 times more likely to have been ill or have blacked out than adult drivers aged 21-64. As shown in Figure 12, the fraction of fatal crashes involving an older adult driver with these medical issues is small (3.3%). However, it is these drivers that the Medical Review of the NJ Motor Vehicle Commission seeks to identify and evaluate prior to these fatal crashes.

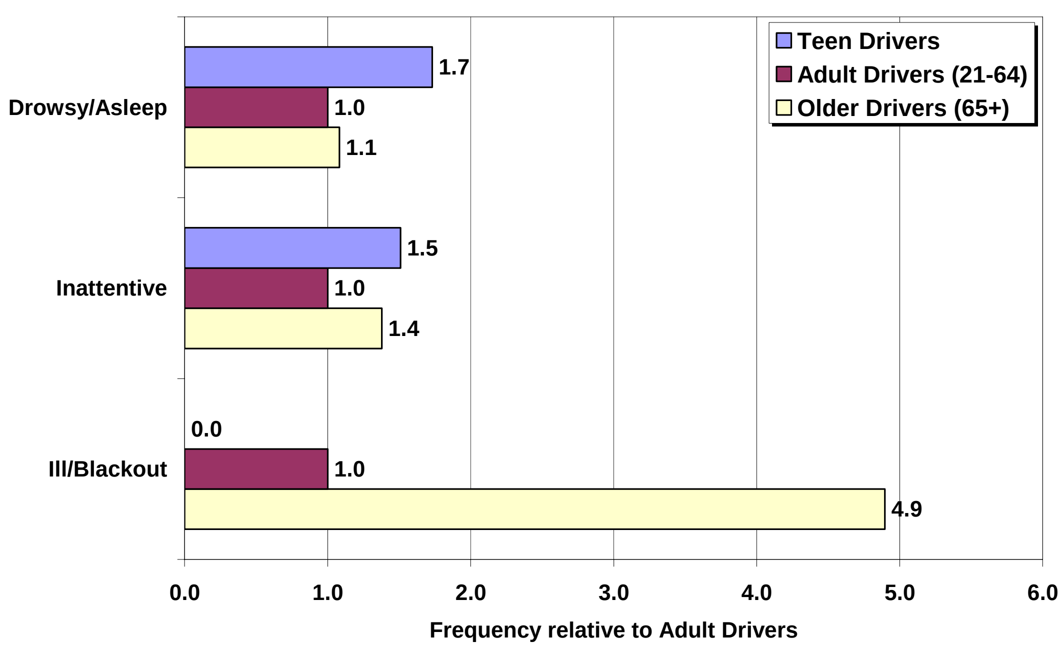

Figure 13. Relative Frequency of Crash-Related Factors for Drivers involved in NJ fatal crashes by Age Group (FARS2001-2006)

As shown in Figure 13, older adult drivers who were involved in fatal crashes were 10% more likely to be drowsy or asleep than adult drivers. Older adult drivers were 40% more likely to have been attentive or distracted than adult drivers. Teen drivers had a parallel experience. Teen drivers who were involved in fatal crashes were 70% more likely to have been drowsy or asleep than adult drivers and 50% more likely to have been attentive or distracted than adult drivers.

References

McGwin G Jr, Chapman V, & Owsley C. (2000). Visual risk factors for driving difficulty among older drivers. Accident; Analysis and Prevention. 32(6), 735-44.

Nelson DE, J Bolen, and M Kresnow. "Trends in Safety Belt Use by Demographics and by Type of State Safety Belt Law, 1987 Through 1993." American Journal of Public Health. 88.2 (1998): 245-9.

Preusser DF, Williams AF, Ferguson SA, Ulmer RG, & Weinstein HB. (1998). Fatal crash risk for older drivers at intersections. Accident; Analysis and Prevention. 30(2), 151-9.

Schlag B. (1993). Elderly drivers in Germany--fitness and driving behavior. Accident; Analysis and Prevention. 25(1), 47-55.

Zhang J, Lindsay J, Clarke K, Robbins G, & Mao Y. (2000). Factors affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario. Accident; Analysis and Prevention. 32(1), 117-25.

NJDOT Bureau of Research
QUARTERLY PROGRESS REPORT

Project Title:	HEAVY METAL CONTAMINATION IN HIGHWAY MARKING BEADS		
RFP NUMBER: 2008-11		NJDOT RESEARCH PROJECT MANAGER: Edward S. Kondrath	
TASK ORDER NUMBER:		PRINCIPAL INVESTIGATOR: Kauser Jahan, Ph.D, P.E. Rowan University Lisa Axe, Ph.D. NJIT	
Project Starting Date:	1/1/2008	Period Starting Date:	January 1, 2008
Project Ending Date:	6/30/2010	Period Ending Date:	March 31, 2008

Task	**% of Total**	**% of Task this quarter**	**% of Task to date**	**% of Total Complete**
1. Literature Search	10	10	10	10
2. Identify methods	20	5	5	5
3. Obtain glass bead samples, reference standards	5	2	2	2
4. Compare XRF and ICP	15	0	0	0
5. Determine metal in select glass beads	20	0	0	0
6. Conduct Batch experiments in presence of salt, various pH etc. to study leaching	20	0	0	0
7. Final Report	10	0	0	0
TOTAL	100			

HEAVY METAL CONTAMINATION IN HIGHWAY MARKING BEADS

Quarterly Progress Report – March 2008

Project Objectives:

The overall goal of this study is to determine the presence of heavy metals in highway marking glass beads and to determine conditions under which the metal may leach from the glass. Results from these experiments would then aid in setting limits on metal content in glass beads. The specific objectives are to:

a) Conduct a literature review on existing limits on metal content in glass beads, chemicals used in roads/highways and identification of foreign vendors who are in the business of glass bead manufacturing using recycled glass.

b) Investigate metal measurement techniques for glass beads;

c) Evaluate select metal concentrations in foreign and domestic glass beads using sophisticated analytical techniques;

d) Conduct batch experiments utilizing glass beads to determine the impact of factors such as abrasion, chemical applications on roadways such as NaCl, pH and time on metal leaching or dissolution. Studying leaching or dissolution from commercial glass beads before application and as a function of simulated roadway weathering will provide the degree to which the potential metal contaminated run-off impacts neighboring surface waters as well as groundwater through infiltration.

Project Abstract:

The glass industry in the USA has been facing economic challenges as more and more foreign glass is entering the market at competitive prices. Currently there is concern and proof that many of these foreign glass beads do not meet the heavy metal content specifications set by various federal regulations for manufacturing and use by various industries. The transportation industry is one of the largest users of glass beads for highway marking. Road markings are among the most efficient and economical means to safely guide traffic. Glass beads are embedded on pavement markings to obtain *retroreflectivity* which is an optical phenomenon that plays a crucial role in maintaining the guiding function of the highway stripings to ensure safe driving. The glass beads embedded in the marking material allow a vehicle's headlight beam to be returned to the driver's eye, which results in a "light-up" effect of the striping. This is the decisive plus for road safety. Integrating glass beads of good optical quality are essential to ensure clear visibility at night. Currently glass beads used by the transportation sector in the USA for highway marking are required to meet the AASHTO MT 247 specifications. While the specification requires certain physical and optical properties in the glass beads there are no federal guidelines for allowable heavy metal content. The allowable heavy

metal content in glass beads also vary state by state in the USA. *Currently there is no cohesive study that has investigated the allowable heavy metal content in glass beads by states nor are there any detailed studies that have investigated the metal content in foreign beads.*

1. Progress this quarter by task:

Task 1 –Literature Review

Metal Content Limits in the USA

A through literature review has been completed on current metal limits in glass beads in the USA and other countries. In the USA the AASHTO and USEPA regulations are followed for glass bead specification. Typically states use the heavy metal limits set for hazardous wastes.

Results indicate that out of the 50 states in the USA, currently the state of Washington is the only one that has set limits on allowable metal concentration in highway marking glass beads. These limits are presented below in Table 1:

Table 1: Allowable Metal Content in Glass beads Set by Washington State

Arsenic	Lead	Antimony	Barium	Cadmium	Chromium	Selenium	Silver	Mercury
20	50	none	100	1.0	5.0	1.0	5.0	0.2

*Concentration in ppm

The above metal limits are the same as the ones set by the USEPA for heavy metal content in hazardous wastes except for arsenic and lead. The arsenic and lead concentration limits set by Washington exceed the USEPA limit of 5 ppm.

The state of California has recently introduced legislation *(1)* to limit the inorganic arsenic concentration in glass beads to 75 ppm. The state currently requires glass bead manufacturers to meet the California Code of Regulations that limits metal content based around the definition of a hazardous waste. The CALTRANS glass bead specification sheet *(2)* states that "Glass beads shall not contain any hazardous materials at levels that would cause the beads to be classified as a hazardous waste under Title 22, Division 4, Section 66261.20 of the California Code of Regulations." The current limit on arsenic is 500 ppm total, and 5 ppm soluble and for lead the limitations are1000 ppm total, and 5 ppm soluble.

The American Association of State Highway and Transportation Officials (AASHTO) are currently reviewing, through its technical committee, standards covering heavy metals in glass because of environmental concerns. The ASSHTO Draft M247-06 proposes:

Less than 20 ppm total arsenic
Less than 80 ppm total antimony
Less than 50 ppm total lead

Similar reviews are taking place in the European Union.

Metal Limits Abroad

Samples of glass beads, collected from around Australia, North America and Europe were analyzed for their chemical composition in order to determine the current market status (3). These samples were found to contain only background traces of heavy metals, which are considered to be consistent as 'naturally occurring' and present in the ingredients that are used in the manufacture of soda-lime glass. This is controlled by the glass manufacturing industry.

However samples of glass beads from some developing countries were found to contain levels of heavy metals which are consistently in the range of 500 to 1500 ppm for arsenic alone. High levels of both antimony and lead were also detected.

Australia and New Zealand recommend for purchasers wishing to use heavy metal content as a key decision maker on environmental grounds, 50 ppm for each heavy metal (As, Sb and Pb), and 10 ppm for each heavy metal (CdO, Hg, Cr_2O_3) be considered.
As a point of reference, ISO 4802-1 food container glass covers the heavy metals arsenic, antimony, lead, cadmium, mercury and chromium. The aggregate total limit is100 ppm, with no single element permitted to exceed 50 ppm.

The quantity of heavy metals in glass beads set by Austrian, Swedish, and Finnish authorities is 200 ppm (mg/kg) for each of the heavy metals[1].

The literature review indicates that there is no widespread agreement on the metal content limitation on glass beads used for highway marking.

Glass Manufacturers

Glass manufacturers in the USA follow the AASHTO and USEPA guidelines in glass bead manufacturing. In developing countries such as China the manufacturers follow the AASHTO specification only.

NIST Standards

All the NIST standards available for various types of glass were also identified.

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[1] *Personal Communication, Potter Industries, R & D Director Ufuk Senturk, March 11, 2008.*

Chemical Use in Roads and Highways

A thorough review of the chemicals used in roads and highways was also conducted *(4).* Literature indicates that deicing chemicals are the most common of the chemicals used in road maintenance. The most common chemical is the chloride salt especially sodium chloride, calcium chloride and potassium chloride. Calcium magnesium acetate and potassium acetate are also being researched as anti icing agents. *Anti-icing* is a road maintenance strategy that tries to keep the bond between ice and the pavement surface from forming. It involves applying ice control chemicals before or at the very beginning of the storm. Using this strategy often reduces total chemical use and allows a higher level of service to the traveling public. Typically all these chemicals work by lowering the freezing point of water. The application rate in New Jersey is about 350 pounds per lane mile *(5)*.

Task 2 – Investigate glass dissolution and metal measurement techniques for glass beads

Structure of Glass:
Glass has an open molecular structure made up tetrahedrally coordinated SiO_4 irregular rings which allow the passage of light. This open structure also has the capacity to accommodate a vast array of elements (*6*). Many elements are added to glass in form of oxides to modify its properties. Hynes and Jonson (*7*) reviewed these additions as network formers such as B_2O_3 and P_2O_5; viscosity reducers to lower melt temperature (e.g. Li_2CO_3, Na_2CO_3, and K_2CO_3); and stabilizers to reduce solubility (e.g. MgO, CaO, SrO, BaO, ZnO, PbO) and increase resistance to chemical attack (e.g. B_2O_3). Other additions include refining agents (e.g., As_2O_3 and Sb_2O_3) for removal of CO_2 bubbles formed during heating, and coloring and decoloring (color compensating) agents such as Cu, Cr, Mn, Fe, Co, Ni, V, Se. Flat and container glasses, which constitute over 80% of total glass production (*8*), consist almost entirely of network formers, viscosity reducers, and stabilizers with the container glass incorporating coloring agents for aesthetics purposes. On the other hand, special glass for optics, stemware, art objects, lead crystal, sealing and cathode ray tubes contain 25 to 40% PbO for increased brilliance, density, refractivity index and radiation absorbance as well as up to 0.4% As_2O_3 and Sb_2O_3 (*7*).

Glass beads are manufactured from virgin materials and up to 90% recycled glass, commonly known as cullet (*9*). Use of cullet lowers the melt temperature and also reduces use of virgin materials and costs of waste glass disposal. While theoretically cullet should include only flat and container glass to minimize inclusion of heavy metals, it is evident that some foreign manufactures do not comply; depending on the manufacturer cullet from special glasses such as light and cathode ray tubes may be used. Metal concentrations in glass beads measured with x-ray fluorescence (XRF) revealed elevated levels of PbO, 70–1150 ppm; As_2O_3, 130–1140 ppm; and Sb_2O_3, 80–840 ppm, in some foreign manufactured beads (*10*). Concentrations of the same oxides in U.S. manufactured beads were below detection limits, typically 10 ppm. Glass has a large capacity (*6)* to retain heavy metals under normal environmental conditions; however, its dissolution in aggressive conditions such as the high pH (*11*) on roadways from salt application during winter could lead to their release. Furthermore, abrasion of beads by tires exposes more surface area to the environment and may result in increased leaching. Therefore, assessment of total heavy metal concentrations in beads and their availability to the environment is necessary.

Most of the research on glass dissolution has involved modeling dissolution rate and, to a lesser extent, determination of its major components; research on total trace metals is not extensive and may in part be due the manufacturing process being strictly controlled with well defined inputs. However, with evidence of heavy metals in glass beads imported to the U.S., the possibility of heavy metals leaching into the environment can not be ignored.

Glass Dissolution and Total Metal Analysis Methods

The summary of possible approaches for glass dissolution and total metal analysis is presented in Table 1. For complete dissolution, digestion with hydrofluoric acid (HF) is the only widely used method that offers complete dissolution and for which standard procedures exist. ASTM C169-92 (*12*) specifies a hot plate method with platinum crucibles for dissolution of soda-lime and borosilicate glass. EPA method 3052 (*13*) details microwave assisted digestion of siliceous and organically based matrices. HF, however, is extremely toxic; its use requires a well developed safety plan. HF also attacks the conventional inductively coupled plasma atomic emission spectroscopy (ICP-AES) borosilicate glass nebulizer, spray chamber, and the quartz torch. Therefore using HF requires either installation of an expensive inert nebulizer or further treatment of digest with $HClO_4$, H_3BO_3, or $AlCl_3$ (*14*). Although glass is attacked by alkalis, microwave digestion with 40% NaOH failed to dissolve the glass completely (*11*). On the other hand, fusion of glass with potassium hydroxide (KOH) following a procedure developed by Pacific Northwest National Laboratory (PNNL) resulted in a water soluble melt (*15, 16*). Analysis of metals with ICP-AES was in close agreement with the known glass composition. However, available results are limited to two studies (i.e. 15, 16). Solid glass analyses offer quick non-analytical assessments; however, they are limited by sensitivity, parts per million (ppm) for XRF and availability of laser ablation ICP-MS. Based on the literature search of glass dissolution and analysis methods, fusion with KOH method is proposed for total metal analysis of glass beads on the bases of safety, complete dissolution, and sensitivity (allows use of ICP-MS).

Table 1 Summary of possible approaches to glass dissolution and total metal analysis

Method	Basis	Advantages	Disadvantages	Ref.
A. Glass Dissolution Approach				
1. Digestion with HF acid	$SiO_2 + 6HF = SiF_6^- + 2H_2O + 2H^+$ Large positive K = 8.0	- Complete dissolution - Standard Methods - Wide usage	- HF extremely toxic -HF attacks measuring devices, require volatilization, or com-plexation with boric acid or $AlCl_3$	*8, 9, 11 - 14 17*
2. Dissolution with alkali	$SiO_2 + H_20 = H_2SiO_3$ $H_2SiO_3 = HSiO_3^- + H^+$ At pH >10	- Less hazardous solvent than HF	- Incomplete dissolution - No standard methods	*11, 17*
3. Fusion with KOH	Solubility of glass/ KOH melt in water and acid	- uses KOH pellets, KNO_3, and oxalic acid only	- Reported by PNL Co. only - Difficulty dissolving and accounting for all fusion - Results only for major components	*15, 16*
B. Solid Glass Analysis				
4. XRF	Florescence of constituent elements	- Analysis of solid glass	- Sensitivity limited to ppm	*10*
5. Laser ablation ICP-MS	Ablation of solids with pulses from a laser. Transfer of released material to ICP	- Elemental analysis of solid glass	- Availability of equipment - Experience mainly in geology, and archaeometry though claims for environmental applications	*18 - 20*

Proposed Procedure

The KOH glass fusion procedure adopted by Brinkley (*15*) and Cerefice (*16*) from PNNL Procedure No. APSL-03 is proposed for dissolution of glass beads. In the procedure, KOH fusion is used to melt the glass which is subsequently dissolved in DI water and the metal concentration measured with ICP-MS. The detailed procedure is as follows. Glass beads are crushed using an agate mortar and pestle until it passes through a 140 mesh (< 100 µm). 0.25 ± 0.075 g of the crushed beads are weighed out into a nickel crucible. 1.8 ± 0.4 g of KOH and 0.2 ± 0.1 g of KNO_3 are added and the contents shaken to mix. The crucible and its contents are then placed onto a burner and heated (500, 700, 750 º C) until the mixture melts after which it cooled to room temperature. Approximately 10 ml of de-ionized (DI) water are added to dissolve the cake-like melt. The solution is then transferred to a 250 ml volumetric flask. The procedure is repeated until all of the melt in the crucible is dissolved. The solution in the flask is then diluted to approximately 100 ml total volume using DI water and acidified using 25 ± 5 ml of concentrated HCl acid to dissolve any precipitate. However, if some precipitate is not dissolved, 0.3 ± 0.1 g of oxalic acid crystals are added. The flask contents are then made up to 250 ml with DI water and stored at $4^{o}C$ until analysis for metals with ICP-MS.

2. Proposed activities for next quarter by task

- Continue development of method for complete dissolution of glass or seek alternatives such as sending samples to an offsite laboratory
- Compare X-ray fluorescence results with ICP results for metal analyses
- Develop batch experiments to determine impact of environmental conditions, such as sodium chloride application, on metal leaching from glass

3. List of deliverables provided in this quarter by task

- None Scheduled

4. Progress on Implementation and Training Activities

- None Scheduled

5. Problems/Proposed Solutions

- None Scheduled

<u>We are currently still processing paperwork for the NJIT subcontract.</u>

Total Project Budget (Year 1) Received to date	$119,461
Total Project Expenditure to date	0.0
% of Total Project Budget Expended	0.0

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APPENDIX

Glass Beads Samples Received

A. Supplied by NJDOT

Sample No.	From	Location	Producer	Lot No.	AASTO M-247 Type	Date Received
1	Potters Industries	Zone Stripping Glassboro, NJ	Potters Industries Postdam, NY	111407	2	1/8/2008
2	Potters Industries	Zone Stripping Glassboro, NJ	Potters Industries Postdam, NY	10507	2	1/8/2008
3	Potters Industries	Denville Rockaway, NJ	Potters Industries Postdam, NY	5016-5	1	1/8/2008
4	Potters Industries	Traffic Lines Farmingdalr, NJ	Swarco Industries Inc Columbia, TN	101070SI	1	1/8/2008

B. Supplied by Flint Trading, Inc.

Supplier	Sample No.	Manufacturer	Country	Type	Supplier Remarks
Flint	1	B	Russia	III	Used in Production
Flint	2	B	Russia	IV	Used in Production
Flint	3	A	North America	I	Used in Production
Flint	4	A	North America	I	Used in Production
Flint	5	C	China	III	Rejected due to Clarity
Flint	6	C	China	I	Used in Production
Flint	7	D	China	I	Rejected because of Heavy Metals

Metals to be analyzed for in glass beads and leacheate, analytical methods detection limits (MDL) and New Jersey Department of Environmental Protection (NJDEP) limits for synthetic precipitation leaching procedure (SPLP) leachate.

	Contaminant	EPA (EPA Method 700a) (μg/L)	GFAA (EPA Method 7010) (μg/L)	ICP (EPA Method 6010c (μg/L)	NJDEP Leachate Limits [a] Based on SPLP (μg/L)
1	Aluminum	100		30	2,600
2	Antimony	200	3	21	78
3	Arsenic		1	35	0.5
4	Barium	100	2	0.87	91,000
5	Beryllium	5	**0.2**	**0.18**	13
6	Cadmium	5	**0.1**	**2.3**	52
7	Cobalt	50	**1**	**4.7**	NA
8	Copper	**20**	**1**	**3.6**	16,900
9	Lead	100	1	28	65
10	Manganese	**10**	0.2	0.93	650
11	Mercury			17	26
12	Nickel	40	1	10	1,300
13	Selenium		**2**	50	520
14	Silver	10	**0.2**	**17**	520
15	Thallium	100	**1**	**0.28**	0.76
16	Vanadium	200	**4**	**5.0**	NA
17	Zinc	**5**	0.05	1.2	26,000
18	Chromium	50	**1**	**4.7**	

Values in blue refer to the proposed method for analysis in this project

NJDOT Bureau of Research
QUARTERLY PROGRESS REPORT

Project Title:	Motorcycle Crash Analysis	
RFP NUMBER: 2008-17		**NJDOT RESEARCH PROJECT MANAGER**: Edward S. Kondrath
TASK ORDER NUMBER: 12		**PRINCIPAL INVESTIGATOR:** Yusuf Mehta, Ph.D, P.E. Rowan University
Project Starting Date: 1/1/2008 **Original Project Ending Date**: 06/30/2009		**Period Starting Date**: January 1, 2008 **Period Ending Date**: March 31, 2008

Task	% of Total	% of Task this quarter	% of Task to date	% of Total Complete
1. Literature Survey	10	50	5	5
2. Survey of Best National and International Practices	10	50	5	5
3. Analysis of New Jersey Motorcycle Accident Rates	15	0	0	0
4. Needs for Enhancements to Motorcycle Training and Licensing	30	0	0	
5. Motorcycle Compatibility with the Highway and the Roadside	15	0	0	
6. Develop Strategic Plan and Recommendations for Improving Motorcycle Safety	10	0	0	
7. Final Report	10	0	0	10
TOTAL	100			

Quarterly Progress Report – March 2007

Project Objectives:

The goal of this project is to develop a strategic plan for the reduction of New Jersey motorcycle accident rates in both fatal and non-fatal crashes. The specific objectives are to:

1) Determine the root causes for New Jersey both fatal and non-fatal motorcycle crashes.

2) Develop specific recommendations for reducing the NJ motorcycle rates which incorporate the unique nature of the New Jersey highway system.

Project Abstract:

Motorcyclists are vulnerable highway users. Unlike passenger vehicle occupants, motorcycle riders have neither the protective structural cage nor the advanced occupant protection systems, e.g. airbags, which are commonplace in cars and light trucks. In 2006, the most recent year of statistics available, there were 87 motorcyclist fatalities in New Jersey. Nationally, as motorcycles become increasingly popular, motorcycle deaths have increased dramatically in the U.S. In New Jersey, motorcyclist fatalities have more than doubled since 1991 while overall highway deaths in the state have remained relatively unchanged over the same time period (NHTSA, 2006).

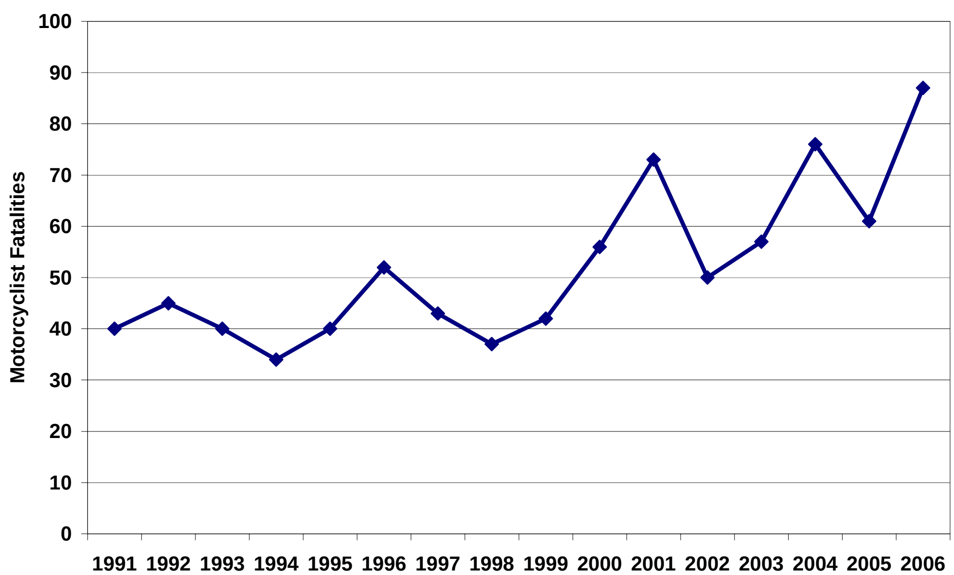

Figure 1. Motorcycle Fatalities in New Jersey (1991-2006)

The factors which lead to fatal motorcycle crashes are a complex combination of motorcyclist behavior, lack of awareness of other motorists, highway design and condition, and the degree of training or experience of the rider. The crash causation factors include the following:

Road User Behavior

- <u>Failure to wear helmets</u>. Our analysis of NJ fatal motorcycle accidents in 2006 shows that 12% of all fatally injured motorcyclists in New Jersey were either not wearing their helmets or were wearing an unapproved helmet.
- <u>Drinking and Motorcyclists</u>. Our analysis of NJ fatal motorcycle accidents in 2006 shows that 31% of all fatally injured motorcyclists (27 of 87) in New Jersey had been drinking. In contrast, 18% of all car drivers involved in fatal crashes had been drinking.
- <u>Older riders</u>. Nationally, motorcyclists involved in fatal crashes are increasingly older. Frequently, these baby boomers, with greater disposable income, riding higher performance motorcycles for which the rider may not be sufficiently experienced (Samaha, 2007). We can expect to see similar trends in coming years in New Jersey.
- <u>Other Motorists</u>. There is a need to educate other motorists to consider motorcycle safety. After crashes, many motorists state they never saw the motorcycle or were unaware of special constraints on motorcyclists, e.g. limits on braking distance.
- <u>Unlicensed motorcycle ridings and reckless drivin</u>g. There is a need to better understand the demographics of riders who either do not have a motorcycle endorsement or have no license at all.
- <u>Better Safety Information.</u> There is a need for more effective dissemination of safety information to motorcyclists. The effectiveness motorcycle safety improvement programs, e.g., post-licensing training programs, are well known among safety experts, but not among the public.

Improved Highway Environments

- <u>Crashes with the roadside</u> are frequently unforgiving for motorcyclists. Our study shows that nationally motorcycle-guardrail collisions now result in more fatalities than car-guardrail fatalities (Gabler, 2007).
- <u>Highway maintenance and upgrades</u> may create crash and injury risks for motorcyclists.
- <u>Highway and roadside designs</u> are focused on cars and trucks, and rarely consider the special needs of motorcyclists.
- <u>Hot spots analysis</u>. There is a need to regularly screen New Jersey crash records to identify locations or hot spots which are particularly dangerous to motorcyclists for possible remediation.

Enhanced Training and Licensing Requirements

- Training instructors for courses, e.g. presented by the Motorcycle Safety Foundation have unique insights into novice rider perceptions and attitudes on safety. There is an opportunity to better understand and improve motorcycle rider performance by drawing on their expertise through interviews or focus groups.
- Need to quantify the crash reduction benefits of novice rider training in practice on New Jersey roads.
- Need for post-license training assessment and assessment. Many riders maintain a motorcycle license endorsement for years after they last rode a motorcycle resulting in rusty skill sets if they resume riding.
- Need to evaluate new strategies for graduated licensing of younger riders. Some states, e.g. Maryland, are now experimenting with GDL programs which do not require adult accompaniment.

The Need for a Strategic Plan
Reductions in motorcycle crash rates will require the joint efforts of all parties involved in motorcycle safety. Stakeholders include motorcycle riders, motorcycle associations, the NJ Motor Vehicle Commission, motorcycle trainers, highway design and maintenance engineers, motorcycle dealers, and law enforcement. Many of these groups have only infrequently worked together in the past, and may view motorcycle safety from completely perspectives. Needed is a strategic plan which, working with these stakeholders, identifies the root causes for New Jersey's high motorcycle crash rates, and develops specific recommendations for improving motorcycle safety in New Jersey

1. Progress this quarter by task:

<u>Task 1 –Literature Survey</u>

A preliminary literature survey has been completed drawing on the research presented at the Transportation research Board An expanded literature survey which will also incorporate international data linking experience is currently underway.

<u>Task 2 – Identify Existing Fatality – Related Databases and Fatality Data Sets in New Jersey.</u>

- In November 2007, the PI. Yusuf Mehta, met with Tom Wright and Scott McNear from new Jersey Motor Vehicles Commission for the kick-off meeting and developed. At the kick-off meeting it was established that the focus of the study would be on training and licensing.

- In December 2007, the Co-PI, Dr. Clay Gabler met with Tom Wright, Scott McNear, and Bill Beans to determine how NJ Crash data could be obtained electronically.

- Based on the kick-off meeting and subsequent discussions with the research team three survey instruments were developed, a) Rider survey, b) Rider coaches survey, and c) Dealer survey. The objective of the survey is to understand the attitudes of the riders and their perception about the training courses and the MVC test These surveys were discussed by a conference call in February 2008 and a subsequent visit by Tom Wright at Rowan University in March 2008. The surveys are attached in Appendix A. The surveys will be distributed by NJMVC with registration and the riders can take the survey online. These surveys will be connected by a unique Identifier. The dealer and rider coaches survey will be distributed by NJMVC and the survey can be taken online or by hard copy.

- The Rowan University Institutional Review Board (IRB) application has been prepared for review and approval of the research team's plan for maintaining the confidentiality of the data

- Our project team has secured access to the NJCRASH electronic database.

- Preliminary analysis of the NJ Crash datasets is underway.

2. Proposed activities for next quarter by task

- Distribute the survey and collate data as the survey results are received
- Conduct field investigation of crash sites closer to Glassboro, NJ.

3. List of deliverables provided in this quarter by task

- Surveys are attached in the appendix.

4. Progress on Implementation and Training Activities

- None Scheduled

5. Problems/Proposed Solutions

- None Scheduled

Total Project Budget	199561.50
Total Project Expenditure to date	19561.15
% of Total Project Budget Expended	10